

FRACTAL POWER LAW IN LITERARY ENGLISH<sup>§</sup>L. L. Gonçalves<sup>†</sup>Departamento de Física Geral,  
Universidade de São Paulo,  
C.P. 66318, 05315-970, São Paulo, SP, Brazil

and

L. B. Gonçalves<sup>††</sup>Departamento de Letras Modernas  
Universidade de São Paulo  
C.P. 2530, 01060-970, São Paulo, SP, Brazil

## Abstract

We present in this paper a numerical investigation of literary texts by various well-known English writers, covering the first half of the twentieth century, based upon the results obtained through corpus analysis of the texts. A fractal power law is obtained for the lexical wealth defined as the ratio between the number of different words and the total number of words of a given text. By considering as a signature of each author the exponent and the amplitude of the power law, and the standard deviation of the lexical wealth, it is possible to discriminate works of different genres and writers and show that each writer has a very distinct signature, either considered among other literary writers or compared with writers of non-literary texts. It is also shown that, for a given author, the signature is able to discriminate between short stories and novels.

Keywords: new applications of statistical mechanics, lexical wealth,  
fractal power law, literary English.

PACS number: 05.90.+m

<sup>†</sup>Corresponding author.

E-mail address: lindberg@fisica.ufc.br

On sabbatical leave from:

Departamento de Física  
Universidade Federal do Ceará,  
Campus do Pici, C.P. 6030,  
60451-970 Fortaleza, Ceará, Brazil

<sup>††</sup>On a post-graduate leave from:

Departamento de Letras Estrangeiras  
Universidade Federal do Ceará  
Av. da Universidade, 2683  
60020-181, Fortaleza, Ceará, Brazil

<sup>§</sup>Work partially financed by the Brazilian agencies CNPq, Finep and Capes.

## 1. INTRODUCTION

The power law distribution of events introduced by the Italian economist Pareto [1], in the context of the wealth of nations and individuals, and restated by Zipf [2] concerning linguistics is perhaps the most ubiquitous law in nature. This power law statistics, which is a characteristic of fractal behaviour, is present in many different areas ranging from physics [3] and biology [4,5] to natural hazards [6,7,8], and from musical creative context [9] to economics [10]. Several applications in linguistics have already been done, but the literary aspects which have been analysed until now are all related to word formation within the literary texts [12,13]. To the best of our knowledge, no attempt has been made to verify the possibility of existence of a Zipf's law type within the literary context. By using the software WordSmith, from Oxford University Press, with electronic texts one is able to obtain the types/tokens ratio, types being the number of different words in a text and tokens, the total number of words in this text. Considering the fact that the types/tokens ratio will necessarily decrease as the tokens increase, we were led to think of a power law distribution, and therefore of relating this behaviour to Zipf's laws.

Although the use of a rich vocabulary is not the sole indication of creativity in a writer, lexical wealth is certainly one characteristic to be expected in a literary writer of the stature of J. Joyce, D. H. Lawrence, V. Woolf., K. Mansfield and others. As a hypothesis, one would expect to find in literary texts a high rate of type/token if compared with non-literary texts, which means that the two genres should follow different Zipf's law.

A second hypothesis would be that, for the same literary author, the rate type/token should be higher in the case of short stories, which belong to a compact genre, rather than with novels, which are more prolix, and therefore less creative in lexical terms. Then, we should be able to identify in quantitative terms these differences.

Therefore, besides verifying a Zipf's law type of behaviour in different texts, two important questions to ask are whether a 'signature' may be attributed to each author, by means of the exponent of the law, and if this signature will change when the literary genre changes. Moreover, it would also be desirable to associate different 'signatures' to different authors, even when they belong to the same literary period.

The purpose of this paper is to answer these questions, by analysing short stories of famous writers, excerpts of novels, as well as non-literary twentieth-century texts. To this aim, electronic corpora were compiled, with 15 short stories by J. Joyce, 12 short stories by D. H. Lawrence, 20 stories by V. Woolf, 17 short stories by K. Mansfield and 24 short stories by various authors. Also excerpts of five of Lawrence's novels and eight excerpts from novels by different authors were compiled. We have also considered 30 non-literary texts compiled from the newspaper The Guardian, selected among various types of subjects.

In section 2 we present the works mentioned above and the results obtained by using WordSmith tools. We also introduce Zipf's law in the literary context. The results are presented in section 3 and the main conclusions are summarized in the concluding remarks in section 4.

## 2. ZIPF'S LAW IN LITERATURE

As described above, one important aspect of the literary work of a given author is its lexical wealth,  $k$ , which is defined as the ratio between the number of types  $n$  (number of different words) and the number of tokens  $N$  (total number of words) of a given text. This quantity can be obtained from the text analysis by using one of the lists, the S-list, given by the WordList tool, provided by WordSmith. In the output we can obtain  $n$ , identified as types,  $N$ , as tokens, and the ratio  $K = 100k(k = n/N)$ , which corresponds to the lexical wealth in terms of percentage.

As pointed out in the Introduction, the lexical wealth represents the main quantitative variable on which we will base our numerical analysis. By assuming a power law behaviour for these quantities we can write

$$N = Ak^{-\phi}, \quad (1)$$

where  $A$  is a constant amplitude and  $\phi$  an exponent which should be characteristics of a given author. We can linearize Eq. 1 by taking the decimal logarithm on both sides of the equation, and from this we obtain

$$\log_{10}(N) = \log_{10}(A) - \phi \log_{10}(k). \quad (2)$$

The previous equation is a straight line in the new variables  $\log_{10}(N)$  and  $\log_{10}(k)$ , and the constants  $\alpha$  [ $\alpha \equiv \log_{10}(A)$ ] and  $\phi$  are determined by means of a linear regression of the data.

The data for different texts and authors analysed in this paper are shown in Tables 1-8. In Tables 1-4 we present the short stories data relative to the authors J. Joyce, D. H. Lawrence, V. Woolf and K. Mansfield, respectively. The short stories data for various writers are shown in Table 5, and the excerpts of novels data by D. H. Lawrence and by different authors are shown in Tables 6 and 7, respectively. Finally, in Table 8, we present the data for non-literary texts, all obtained from recent issues of the newspaper The Guardian. It should be noted that the rather large values of  $K$ , for non-literary texts shown in this table, when compared with the literary ones points to an apparent high lexical wealth which is a consequence of the relatively small values of  $N$  for the articles considered.

The texts and authors have been chosen in such a way that we could have very specific literary genres and representatives writers. In particular in order to characterize the novels, which constitute a very important genre, we have considered excerpts from five of D. H. Lawrence's novels to verify whether there was any change within the writings of a same author, depending on his writing a short story or a novel. Eight different novelists were studied so that we had a comparable number against which to judge the results with Lawrence's novels.

A comparison with non-literary was essential in the sense that it would be a validation of our study and, therefore journalistic texts were considered.

### 3. RESULTS AND DISCUSSION

The results for the linear regression of the data corresponding to short stories by J. Joyce , D. H. Lawrence, V. Woolf and K. Mansfield are shown in Figs. 1-4 respectively, and in Fig. 5 are shown the results for short stories by different authors. In Figs. 6 and 7 are presented the results for the novels of D. H. Lawrence and novels of various authors respectively. Finally in Fig.8 we present the data for non-literary texts.

The results show clearly that a power law is satisfied in all cases with some acceptable fluctuation in the parameters  $\alpha$  ( $\alpha \equiv \log A$ ) and  $\phi$ . In literary terms, we may consider  $A$  and  $\phi$  as signatures of the authors. For example, we can observe that in the limit  $k \rightarrow 1$  we have  $N = A = n$ , which gives, in theoretical terms, the number of words an author may write before he repeats a word. The parameter  $\phi$  will determine how rapidly, or slowly, repeated words are introduced in the discourse, which is typical for each writer.

In the case of the short stories by different authors, as expected, the dispersion of the data from the power law is more pronounced (Fig. 5), as we were dealing with different signatures of the same work. The least dispersions are presented by Lawrence and Mansfield's short stories, as can be seen in Figs. 2 and 4, respectively.

Identical behaviour for different authors is also observed when the novels are considered, as shown in Figs. 6 and 7, and the largest dispersion is present in the non-literary texts shown in Fig. 8. This is an indication that a measure of this dispersion,  $\chi = 100\eta$ , where  $\eta$  is the standard deviation of the linear fitting, can be used as a parameter to discriminate the authors and genres of literary works.

In the literary perspective,  $\chi$  will indicate the consistency of a writer, for any value of  $k$ , and it is remarkable in this aspect the result for Lawrence's novels. It is worthwhile to consider that, when dealing with short stories, where  $N$  is usually small, the dispersion interferes more substantially in the calculation of  $\chi$ . In the newspaper texts, although the context imposes a series of norms in writing, we can find a high  $\chi$ , which identifies these texts as non-literary.

We can also define an important additional parameter, related to the uniformity of the lexical wealth. This is the standard deviation of the  $K$ , which we define as  $\sigma$ . Certainly it constitutes a typical personal parameter, since it is directly related to the lexical wealth of the author, and it has been recently introduced in the context of the characterization of climate of different regions in the United States from the analysis of maximum daily temperature time series[14]. In literary terms,  $\sigma$  will have to do with the preservation of lexical wealth, and with different sizes of the analyzed texts. Thus, the novels, either by D. H. Lawrence or by different authors, will have lower  $\sigma$ 's also due to the fact that the excerpts had similar lengths.

The values of the indices for various authors and genres are summarized in Table 9, and they will be used as their signatures. The identification of the various authors and genres through fractal indices follows a procedure which has been recently used in the description of different complex systems. Examples of such a procedure can be found in our recent paper on the characterization of acoustic emission signals [15], and in various references quoted therein.

From the analysis of these values we can conclude that the various genres tend to occupy separate regions of the four-dimensional space generated by these parameters, as in the case of ref. [15]. This can be seen more clearly in the projection of the points in different planes shown in Figs. 9-11, and it should be noted that these projections do not represent functions of the shown variables. Although this separation is not very well defined in the diagram shown in Fig. 9 (a), where the novels are not completely segregated, the separation of genres are very well marked in all the other diagrams shown in Figs. 9(b), 10(a,b) and 11(a,b). This remarkable result can also be seen in the three-dimensional plots, shown in Figs. 12-15, which correspond to projections of the points on the three dimensional subspaces. And it shows that, although various writers can be differentiated by their signatures in the way shown above, the genres of their writing can be identified as clearly, as it was observed for short stories, novels and newspaper articles.

Although it was not the objective of our study, we have verified that the characteristic parameters for power law, which relates the total number of letters of given text with the number of words, is dependent on the size of the text. The exponent of the power law, which is equal to one [16], can only be obtained correctly when we consider statistically representative samples which is consistent with the results of Pöschel et al.[17]

In order to verify the presence of similar effect on our characteristic parameters, we have analysed excerpts of Lawrence's novels with different sizes. Differently from the previous power law, which is defined in the context of linguistics, no significant variation in the parameters was observed. This is an indication that the usual statistical approach used in linguistic should not be applied to study of literary texts.

Finally, we can conclude from the results presented in the Figs. 9-15 that, besides identifying the genres, the parameters  $\chi$ ,  $\sigma$ ,  $\alpha$  and  $\phi$ , are also characteristic of each author. In particular it should be noted that even within a literary genre, short stories or novels, these indices discriminate the work of different authors as well as a collection of works by many authors. Therefore, they constitute the literary signature of the genres, authors and group of authors.

#### 4. CONCLUDING REMARKS

We have shown, from the corpus analysis of the literary production of English authors and non-literary texts, that a power fractal law can be associated with the lexical wealth of the authors. The parameters defined in the power law, the standard deviation of the power law fitting and the standard deviation of the lexical wealth can be used to characterize each writer and genre and to discriminate a literary from a non-literary text. This discrimination among

authors, different literary texts, namely, short stories and novel, and non-literary articles is present in all the two-dimensional diagrams built with the parameters  $\phi$ ,  $\alpha$ ,  $\chi$  and  $\sigma$ , as has been shown in Figs. 9-11. The three dimensional plot constructed with these parameters are shown in Figs.12-15, and they clearly present the separation among the different authors and styles.

We believe, from the results presented in this work, that the statistical analysis introduced by Corpus Linguistic can increase objectivity in literary studies, opening a wide field for further research.

In order to give further support to this conclusion, following Havlin [18], we introduce a distance from Zipf plots for a given set of data of the authors and genres as

$$d_{AB} = \sqrt{\frac{1}{N_A N_B} \sum_{i,j} (\bar{K}_i^A - \bar{K}_j^B)^2}, \quad (3)$$

where A and B identify the authors and genres,  $i$  and  $j$  the different works in a given genre,  $N_{A(B)}$  is the total number of works considered for a given author and genre, and  $\bar{K}_\beta^\alpha$  is given by

$$\bar{K}_\beta^\alpha = K_\beta^\alpha - \tilde{K}_\beta^\alpha, \quad (4)$$

where  $\tilde{K}_\beta^\alpha$  is obtained from the linear regression of Eq. (2). Eq.(3) can also be applied when the authors A and B are identical, and, in this case, the distance  $d_{\alpha\alpha}$  measures the deviation of the data from a Zipf plot.

The results obtained are presented in Table 10 which, by construction, corresponds to a symmetric matrix. As expected, the shortest distances correspond to the ones related to a same author, and, for a given author, there are different distances for different authors and genres. These results are similar to the ones obtained by Vilensky [19] in the context of Linguistics and gives support to the proposed discrimination within our fractal analysis.

## ACKNOWLEDGEMENTS

The authors would like to thank Dr. A. P. Vieira and Dr. J. P. de Lima for relevant remarks and a critical reading of the manuscript. We would also like to thank the anonymous referee for making us aware of the works by Havlin [18] and Vilensky [19] on the definition and use of the concept of distance among Zipf plots.

## REFERENCES

1. V. Pareto, *Cours d'économie politique professé à l'Université de Lausanne*, (Rouge, 1897)
2. G. K. Zipf, *Selective Studies and the Principle of Relative Frequency in Language* (Harvard University Press, 1932)  
G. K. Zipf, *Psycho-Biology of Languages* (Houghton-Mifflin, 1935; MIT Press, 1965).

- G. K. Zipf, *Human Behavior and the Principle of Least Effort* (Addison-Wesley, 1949).
3. D. Sornette, *Critical phenomena in natural sciences: chaos, fractals, self-organization and disorder: concepts and tools*, 2nd edn. (Springer, 2004)
  4. V. V. Solov'yev, *Biosystems* **30**, 137 (1993)
  5. B. Suki, A. L. Barabási, Z. Hantos, F. Peták, and H. E. Stanley, *Nature* **368**, 615 (1994)
  6. S. Hergarten, *Natural Hazards and Earth System Sciences* **4**, 309 (2004)
  7. B.D. Malamud, D. L. Turcotte, F. Guzzetti and P. Reichenbach, *Earth Surface Processes and Landforms* **29**, 309 (2004)
  8. D. L. Turcotte, *Fractals and Chaos in Geology and Geophysics*, 2nd edn (Cambridge University Press, 1997)
  9. D. H. Zanette, *cs.CL/0406015*
  10. R. N. Mantegna and H. E. Stanley, *An Introduction to Econophysics: Correlations and Complexity in Finance* (Cambridge University Press, 1999)
  11. A. Gelbukh and G. Sidorov, *Lecture Notes in Computer Science* **2004**, 332 (2001)
  12. W. Ebeling and T. Pöschel, *Europhys. Lett.* **26**, 241 (1994)
  13. A. Eftekhari, *cs.CL/0408041*
  14. M.L. Kurnaz, *J. Stat. Mech.: Theor. Exp.* P07009 (2004)
  15. F.E. Silva, L.L. Gonçalves, D.B.B. Ferreira and J.M.A. Rebelo, *Chaos, Solitons & Fractals* **26**, 481 (2005).
  16. R. Perling, *Phys. Rev. B* **54**, 220 (1996).
  17. T. Pöschel, W. Ebeling, C. Frömmel and R. Ramirez, *Eur. Phys. J. E* **12**, 531 (2003).
  18. S. Havlin, *Physica A* **215**, 148 (1995).
  19. B. Vilensky, *Physica A* **231**, 705 (1995).

## FIGURE CAPTIONS

- Fig. 1 - Linear fit of  $\log_{10}(N)$  as a function of  $\log_{10}(k)$  for short stories by J. Joyce.
- Fig. 2 - Linear fit of  $\log_{10}(N)$  as a function of  $\log_{10}(k)$  for short stories by D. H. Lawrence.
- Fig. 3 - Linear fit of  $\log_{10}(N)$  as a function of  $\log_{10}(k)$  for short stories by V. Woolf.
- Fig. 4 - Linear fit of  $\log_{10}(N)$  as a function of  $\log_{10}(k)$  for short stories by K. Mansfield.
- Fig. 5 - Linear fit of  $\log_{10}(N)$  as a function of  $\log_{10}(k)$  for short stories by various authors.
- Fig. 6 - Linear fit of  $\log_{10}(N)$  as a function of  $\log_{10}(k)$  for excerpts of novels by D. H. Lawrence.
- Fig. 7 - Linear fit of  $\log_{10}(N)$  as a function of  $\log_{10}(k)$  for excerpts of

novels by various authors.

- Fig. 8 - Linear fit of  $\log_{10}(N)$  as a function of  $\log_{10}(k)$  for excerpts of non-literary texts.
- Fig. 9 - (a) Percentage standard deviation of the linear fitting,  $\chi$ , and (b) logarithm of the amplitude of the power law,  $\alpha$ , as functions of the power law exponent,  $\phi$ , for different authors, genres and non-literary texts.
- Fig. 10 - Standard deviation of  $K$ ,  $\sigma$ , (a) as a function of the power law exponent,  $\phi$ , and (b) as a function of the percentage standard deviation of the linear fitting,  $\chi$ , for different authors, genres and non-literary texts.
- Fig. 11 - Logarithm of the amplitude of the power law,  $\alpha$ , (a) as a function of the standard deviation of  $K$ ,  $\sigma$ , and (b) as a function of the percentage standard deviation of the linear fitting,  $\chi$ , for different authors, genres and non-literary texts.
- Fig. 12 - Standard deviation of  $K$ ,  $\sigma$ , as a function of the power law exponent,  $\phi$ , and of the logarithm of the amplitude of the power law,  $\alpha$ , for different authors, genres and non-literary texts.
- Fig. 13 - The standard deviation of  $K$ ,  $\sigma$ , as a function of the power law exponent,  $\phi$ , and of the percentage standard deviation of the linear fitting  $\chi$ , for different authors, genres and non-literary texts.
- Fig. 14 - The logarithm of the amplitude of the power law,  $\alpha$ , as a function of the percentage standard deviation of the linear fitting,  $\chi$ , and of the power law exponent,  $\phi$ , for different authors, genres and non-literary texts.
- Fig. 15 - The logarithm of the amplitude of the power law,  $\alpha$ , as a function of the percentage standard deviation of the linear fitting  $\chi$  and of the standard deviation of  $K$ ,  $\sigma$ , for different authors, genres and non-literary texts.



# TABLES

Titles	$N$	$n$	$K$
After the race	2255	853	37.83
A little cloud	5063	1361	26.88
A mother	4605	1177	25.56
An encounter	3281	976	29.75
A painful case	3672	1231	33.52
Araby	2367	822	34.73
Clay	2686	719	26.77
Counterparts	4201	1092	25.99
Eveline	1842	625	33.93
Grace	7745	1766	22.80
Ivy day in the committee room	5487	1210	22.05
The boarding house	2850	933	32.74
The dead	16006	2702	16.88
The sisters	3169	888	28.02
Two gallants	3984	1134	28.46

Table 1. Short stories by J. Joyce.  $N$  is the number of tokens,  $n$  is the number of types and  $K = 100n/N$ .

Titles	$N$	$n$	$K$
A fragment of stained glass	4044	1046	25.87
A sick collier	2505	792	31.62
Daughters of the vicar	19902	3012	15.13
Goose fair	3990	1180	29.57
Older of chrysanthemums	7806	1671	21.41
Second best	3095	997	32.21
The christening	3604	1099	30.49
The Prussian officer	9163	1793	19.57
The shades of spring	5477	1397	25.51
The shadow in the rose garden	4912	1175	23.92
The thorn in the flesh	7303	1708	23.39
The white stocking	8379	1684	20.10

Table 2. Short Stories by D. H. Lawrence.  $N$  is the number of tokens,  $n$  is the number of types and  $K = 100n/N$ .

Titles	$N$	$n$	$K$
A summing up	1340	554	41.34
An unwritten novel	4667	1393	29.85
A woman's college from outside	1321	568	43.00
In the orchard	1008	417	41.37
Kew gardens	2656	902	33.96
Lappin and Lappinova	3259	997	30.59
Moments of being	2728	837	30.68
Mrs. Dalloway in Bond Street	3139	986	31.41
Solid objects	2415	859	35.57
Society	5472	1414	25.84
The duchess and the jeweller	2505	823	32.85
Together and apart	2288	764	33.39
The legacy	3062	797	29.03
The lady in the looking glass	2231	746	33.44
The man who loved his kind	2385	738	30.94
The mark on the wall	3178	1071	33.70
The new dress	3276	949	28.97
The searchlight	1617	486	30.06
The shooting party	2954	896	30.33
The string quartet	1511	726	48.05

Table 3. Short Stories by V. Woolf.  $N$  is the number of tokens,  $n$  is the number of types and  $K = 100n/N$ .

Titles	$N$	$n$	$K$
An ideal family	2524	786	31.14
At the bay	13746	2438	17.74
Bliss	4898	1170	23.89
Bank holiday	1264	582	46.06
Her first ball	2634	801	30.41
Life of Ma Parker	2643	778	29.44
Marriage à la mode	3925	1075	27.39
Miss Brill	2020	672	33.27
Mr. and Mrs. Dove	3537	892	25.22
Prelude	17123	2678	15.64
The daughters of the late colonel	7253	1404	19.36
The garden party	5567	1256	22.56
The lady's maid	2239	560	25.01
The singing lesson	2137	681	31.87
The stranger	4694	1064	22.67
The voyage	3224	909	28.19
The young girl	2278	712	31.26

Table 4. Short Stories by K. Mansfield.  $N$  is the number of tokens,  $n$  is the number of types and  $K = 100n/N$ .

Titles	Authors	$N$	$n$	$K$
A girl in it	R. Kenney	4248	1296	30.51
A hedonist	J. Galsworthy	2760	1018	36.88
Broadsheet ballad	A. E. Coppard	2824	738	26.13
Empty arms	R. Pertwee	5083	1367	26.89
Genius	E. Mordaunt	8767	1865	21.27
Lena Wrace	M. Sinclair	4931	1073	21.76
Major Willbraham	H. Walpole	6425	1463	22.77
Once a hero	H. Brighthouse	5946	1401	23.56
Seaton's aunt	W. de la Mare	12100	2516	20.79
The backstairs of the mind	R. Langbridge	1624	614	37.81
The bat and Belfry Inn	A. Graham	5527	1459	26.40
The birth of a masterpiece	L. Malet	4284	1545	36.06
The christmas present	R. Crompton	1556	533	34.25
The devil to pay	M. Pemberton	5092	1287	25.27
The dice thrower	S. Southgate	3138	971	30.94
The lie	H. Horn	863	365	42.29
The looking-glass	J. D. Beresford	8522	1742	20.44
The olive	A. Blackwood	4076	1264	31.01
The pensioner	W. Caine	1650	570	34.55
The reaper	D. Easton	1581	652	41.24
The song	M. Edginton	4688	1206	23.75
The stranger woman	G. B. Stern	5264	1608	46.36
The woman who sat still	P. Trustcott	2945	869	39.60
Where was Wych Street	S. Aumonier	5929	1617	27.27

Table 5. Short Stories by various authors.  $N$  is the number of tokens,  $n$  is the number of types and  $K = 100n/N$ .

Titles	$N$	$n$	$K$
Kangaroo	18609	3131	16.83
Lady Chatterley's lover	32293	4154	12.86
Sons and lovers	33821	4395	12.99
The rainbow	29322	3982	13.58
Women in love	38964	4828	12.39

Table 6. Excerpts of novels by D. H. Lawrence.  $N$  is the number of tokens,  $n$  is the number of types and  $K = 100n/N$ .

Titles	Authors	$N$	$n$	$K$
Allan Quatermaine	H. R. Haggard	15847	2960	18.68
Jeremy and Hamlet	H. S. Walpole	34007	189594	11.90
Kim	R. Kipling	24730	4041	16.34
Men are like gods	H. G. Wells	35760	5373	15.03
Mrs. Dalloway	V. Woolf	40054	5446	13.60
The moon and sixpence	W. S. Maugham	20334	3311	16.28
The secret of Father Brown	G. K. Chesterton	48610	5392	11.09
The white monkey	J. Galsworthy	46105	5576	12.09

Table 7. Excerpts of novels by various authors.  $N$  is the number of tokens,  $n$  is the number of types and  $K = 100n/N$ .

Titles	Authors	$N$	$n$	$K$
2001 Odyssey	R. Bray	1651	727	44.03
Arsenal boss? I could be	I. Ridley	2253	648	28.76
Blair claims a Tory crown	K. Ahmed	302	185	61.26
Briton among 20 killed in ambush	J. Steel	449	237	52.78
Bubbles bursts	J. Martinson et al.	1143	504	44.09
Child of a dream	M. Benn	1605	630	39.25
Coal makes Oslo king of the isles	P. Brown	939	419	44.62
Courts make Bush confront race issue	D. Campbell	575	289	49.74
Dodgy wigs, extravagant costumes...	J. Mortimer	1374	592	43.09
Ferrying around	P. Daoust	1499	670	44.70
Foyer to the future	J. Freedland	1229	537	43.69
French bons vivants take a battering	J. Henley	811	426	52.53
Full fifth round draw	D. Fifield	292	175	59.93
Get your kit out	N. Holford	203	118	58.13
Green light for Sorrel £35m	D. Atkinson	570	277	48.60
Hitchcock veteran finally makes his ...	M. Kennedy	481	241	50.10
India and Pakistan are ...	M. Tran	778	419	53.86
Love-hate relationship with Woodhead	R. Allison	313	184	59.79
Mandelson resigns	J. O'Farrel	825	414	50.18
Neighbours in need	D. Brown	734	400	54.50
New quake scare	O. Bowcott	376	222	59.04
Partying in the pink	N. McIntosh	1490	596	40.00
Prosperous old capital strains ...	P. Hetherington	637	317	49.76
Racing	T. Paley	218	136	62.39
Rostrum	J. Brennan	637	277	43.49
Smoke screen	C. Arnot	1014	465	45.86
The pursuit of leisure	L. Brooks	1671	796	47.64
Theft and murder in the Balkans	D. Brown	726	399	54.96
Thumbs up for Scott's Gladiator	D. Campbell et al.	836	380	45.45
Two-minute fight for BA2069	J. Vasagar et al.	760	328	43.16

Table 8. Non-literary texts.  $N$  is the number of tokens,  $n$  is the number of types and  $K = 100n/N$ .

Author/Genre	$\chi$	$\phi$	$\sigma$	$\alpha$
D. H. Lawrence	6.12	2.39	5.52	2.31
K. Mansfield	9.56	2.58	6.88	2.10
J. Joyce	10.18	2.47	5.17	2.24
V. Woolf	11.85	2.07	5.55	2.41
Short stories	14.22	2.54	6.30	2.20
D. H. Lawrence (novels)	1.99	2.29	1.60	2.49
Novels	8.13	1.97	2.48	2.82
Texts	15.36	3.26	7.51	1.84

Table 9. Characteristic indices of the various authors and genres.

Author/Genre	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
D. H. Lawrence (1)	<b>2.08</b>	32.93	30.27	22.46	32.22	40.99	35.42	42.58
K. Mansfield (2)	32.93	<b>3.39</b>	31.28	22.17	31.74	44.28	39.22	36.98
J. Joyce (3)	30.27	31.28	<b>3.77</b>	23.20	33.84	42.34	38.06	39.73
V. Woolf (4)	22.46	22.17	23.20	<b>16.18</b>	39.48	60.07	52.71	39.43
Short stories (5)	32.22	31.74	33.84	39.48	<b>5.63</b>	43.07	36.93	27.85
D. H. Lawrence (novels) (6)	40.99	44.28	42.34	60.07	43.07	<b>0.28</b>	18.67	46.12
Novels (7)	35.42	39.22	38.06	52.71	36.93	18.67	<b>1.66</b>	53.45
Texts (8)	42.58	36.98	39.73	39.43	27.85	46.12	53.45	<b>7.33</b>

Table 10. Zipf distances among different authors and genres.